FILLED BOLOMETER ARRAYS FOR THE HERSCHEL/PACS PHOTOMETER

P. AGNÈSE

LIR/LETI CEA GRENOBLE

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Detector design drivers

Large format to achieve PSF full sampling
Good production yield
Possibility of space qualification
High background applications (NEP = 10^{-16} W Hz$^{-0.5}$)
Operating temperature at 300 mK

Design main features

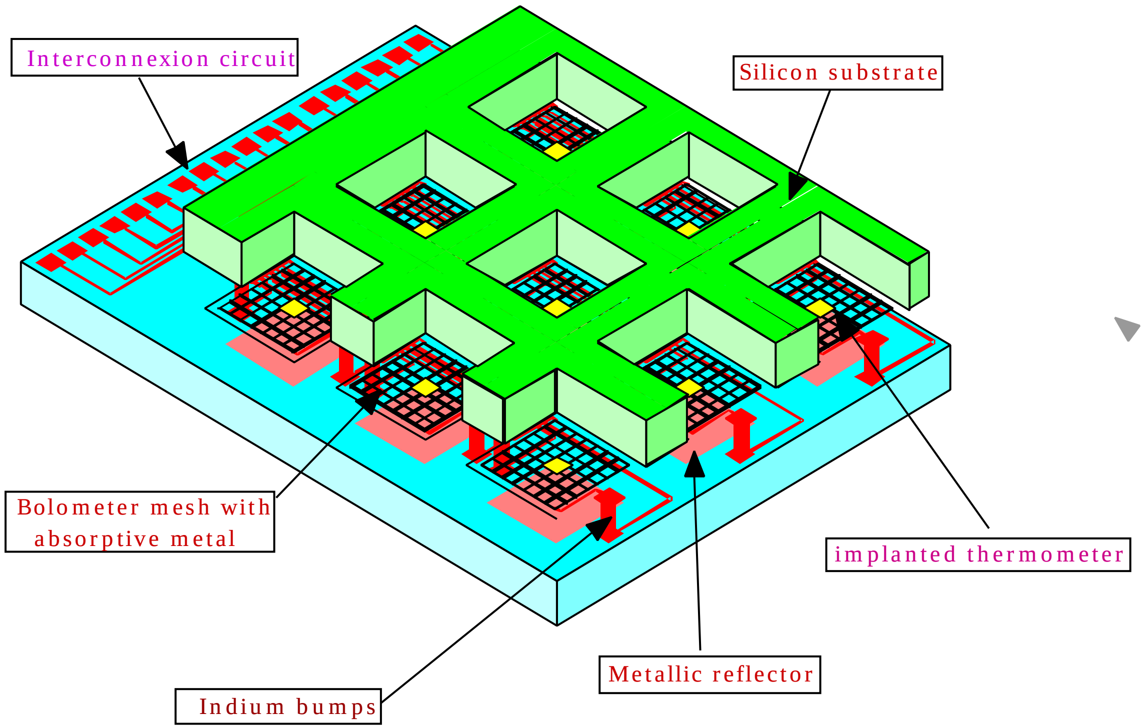
All Silicium technology

Absorption in resonant metal mesh supported by suspended silicon grids

Thermometer in compensated implanted Si

Quarter wave cavity by indium bump

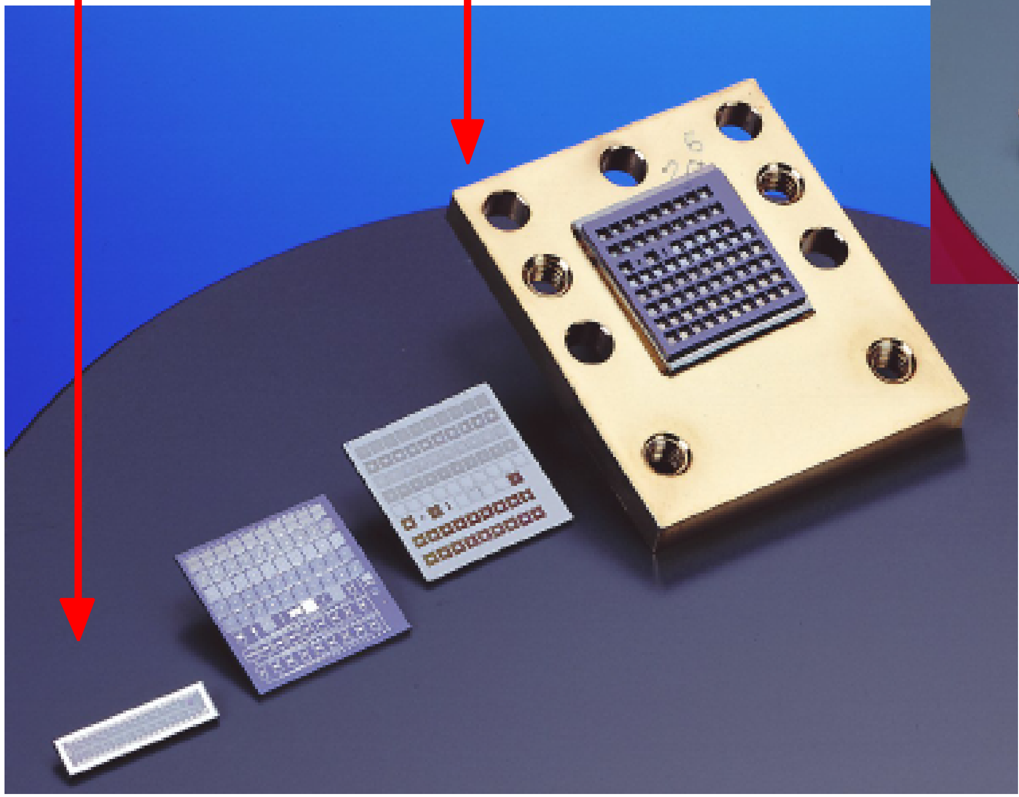
Cold readout and multiplexer electronics in Si MOS technology

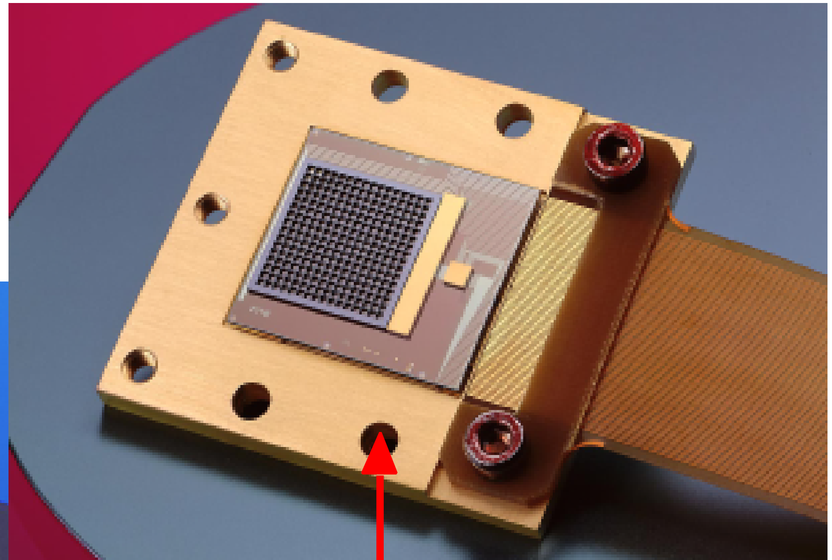


Technology evolution since 1997

1997

1998





1999

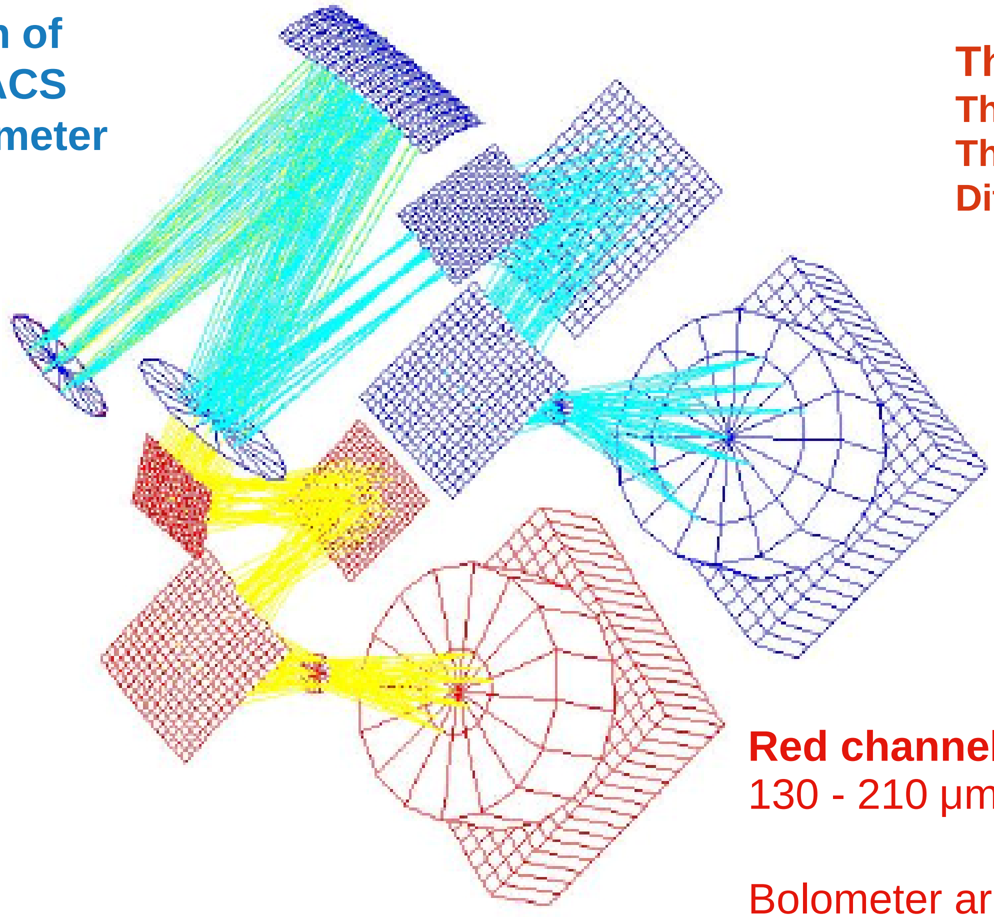
PACS on Herschel

A photometer and spectrograph instrument in the Far-infrared (60 - 200 µm)

PI Albretch Potglitch, MPE, Garching, Germany

Bolometers are used on the photometers
Photoconductors are used on the spectrograph

Optical design of the PACS photometer



The two bolometer arrays have
The same pixel pitch
The same cold readout electronics
Different grid design

Blue channel
60 - 90 µm
90 - 130 µm

Bolometer array : 32 x 64

Red channel
130 - 210 µm

Bolometer array : 16 x 32

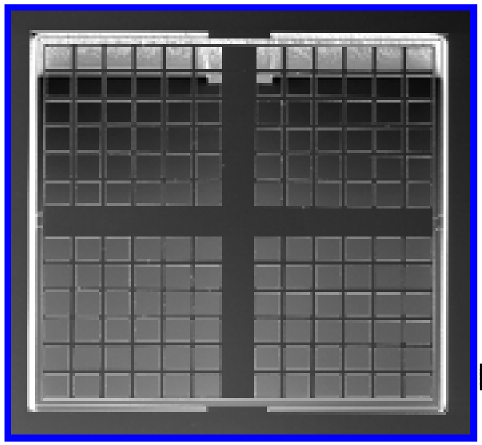
Improvements for the PACS bolometer design

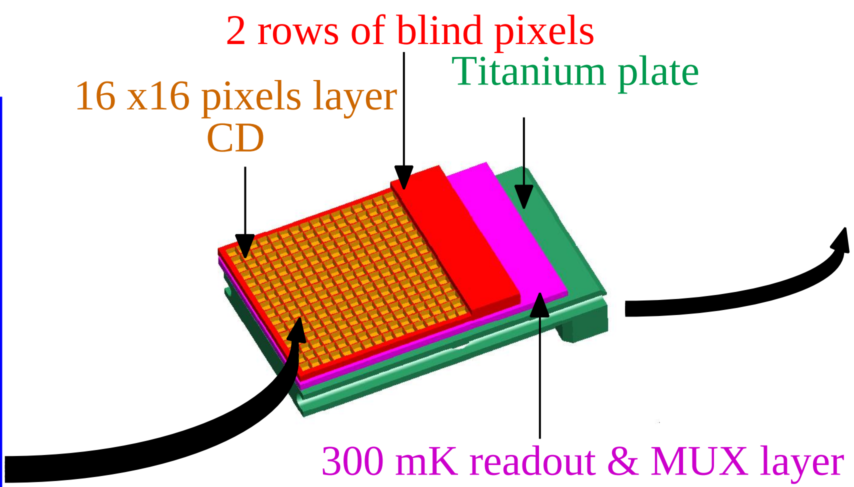
- New grid design adapted to the PACS wavelengths
- SI grid and thermometer manufactured on a double SOI wafer
- New design of mechanical support to ensure 3 side buttability : (gap 750 μm = 1 pixel)
- MOS follower and multiplexer implanted in the interconnection circuit
- MOS preamplifier at 2K
- Mechanical support and mounting tools for array manufacturing

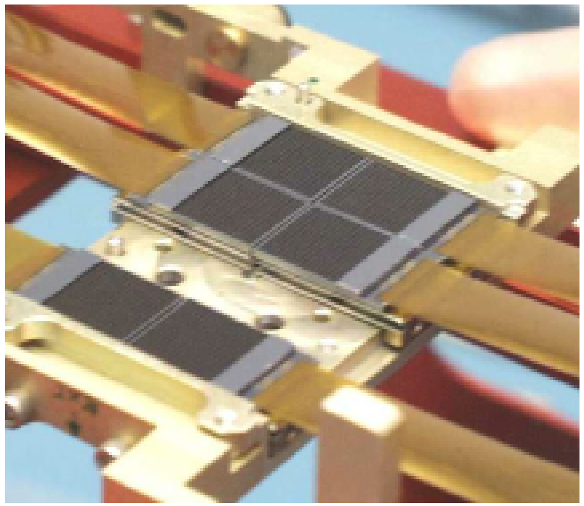
BLUE ARRAY CONFIGURATION

THE 16 X 18 SUB-ARRAY

THE PIXEL





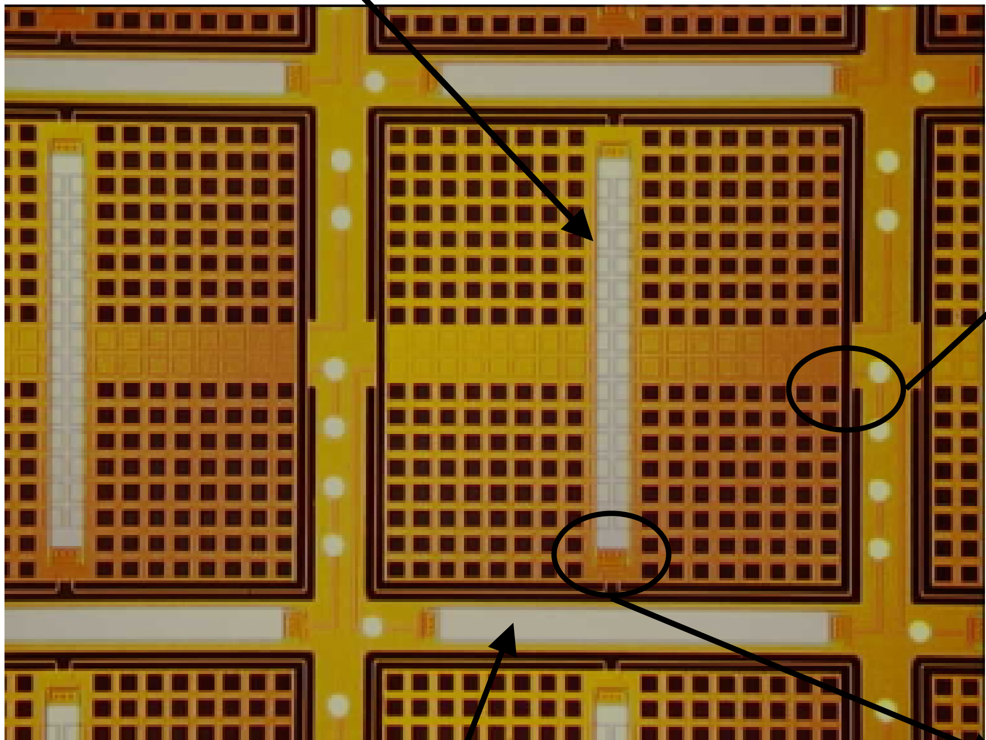


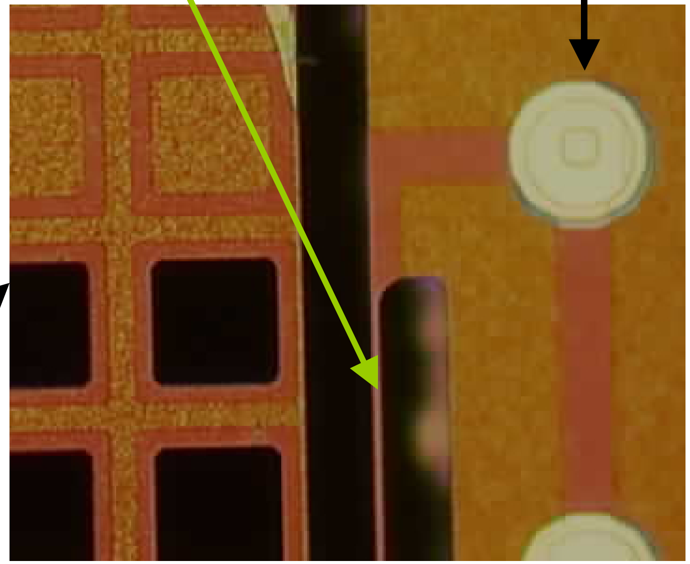
PACS bolometer pixel design

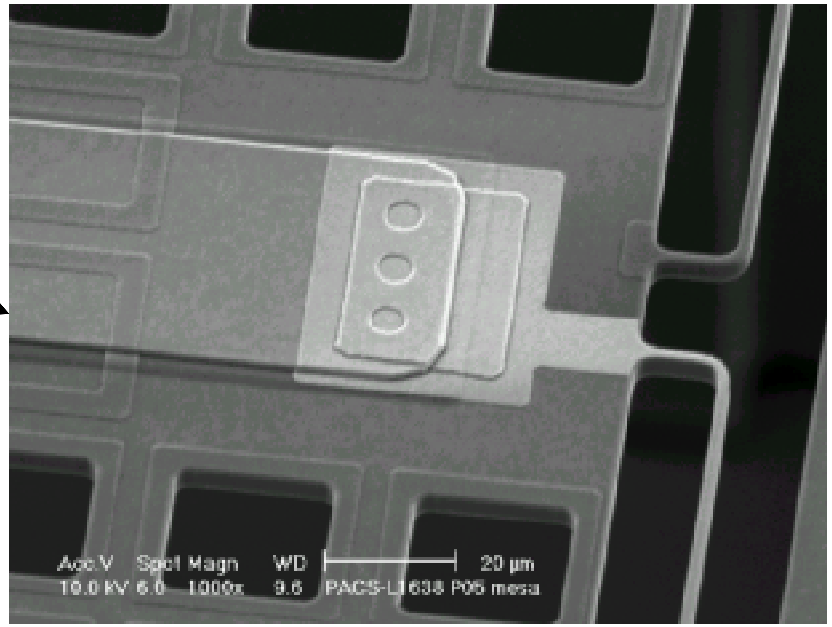
Indium bump pad

2 µm x 5 µm Si suspension rod

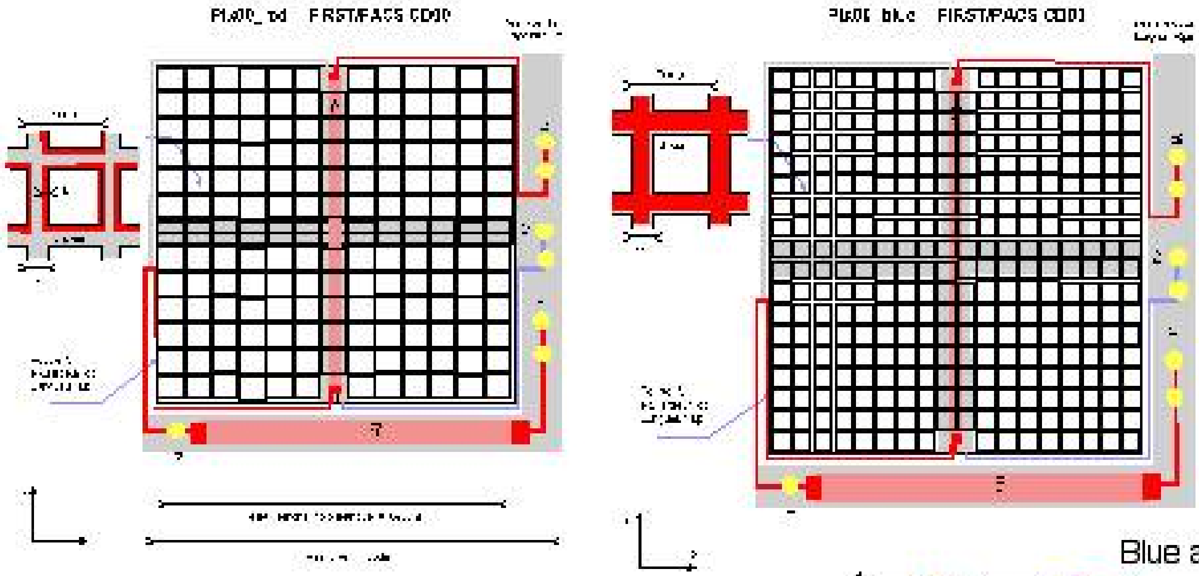
Bolometer thermometer on suspended grid



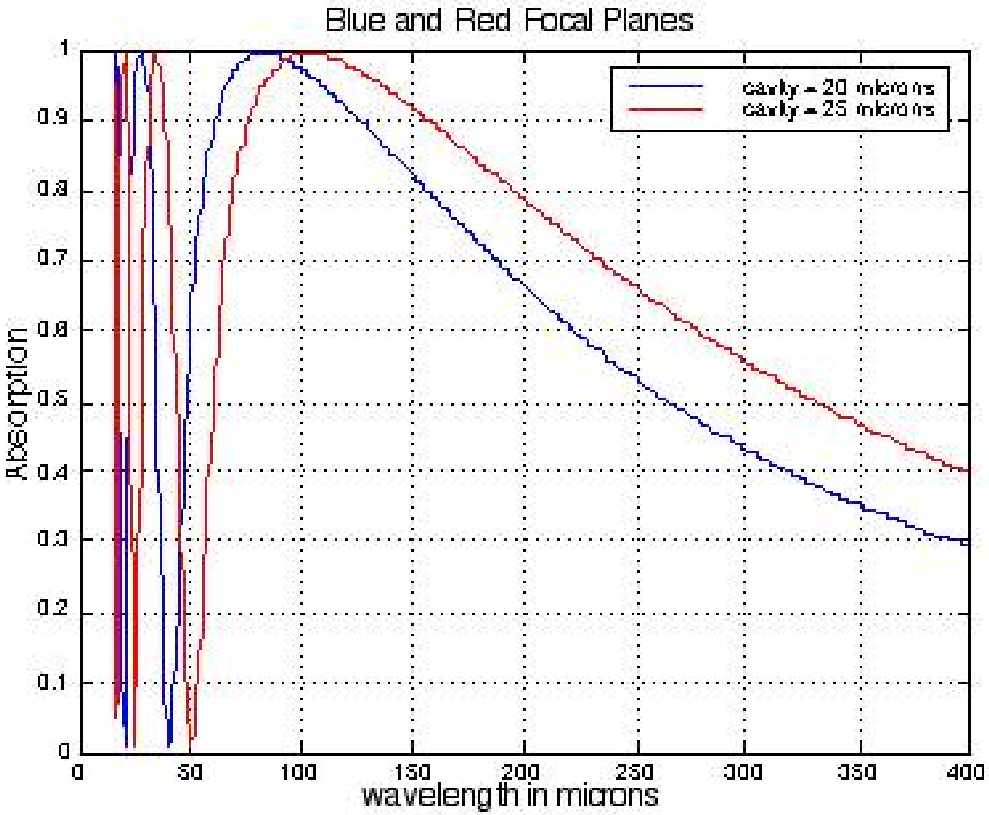




Reference thermometer on Si subtrate

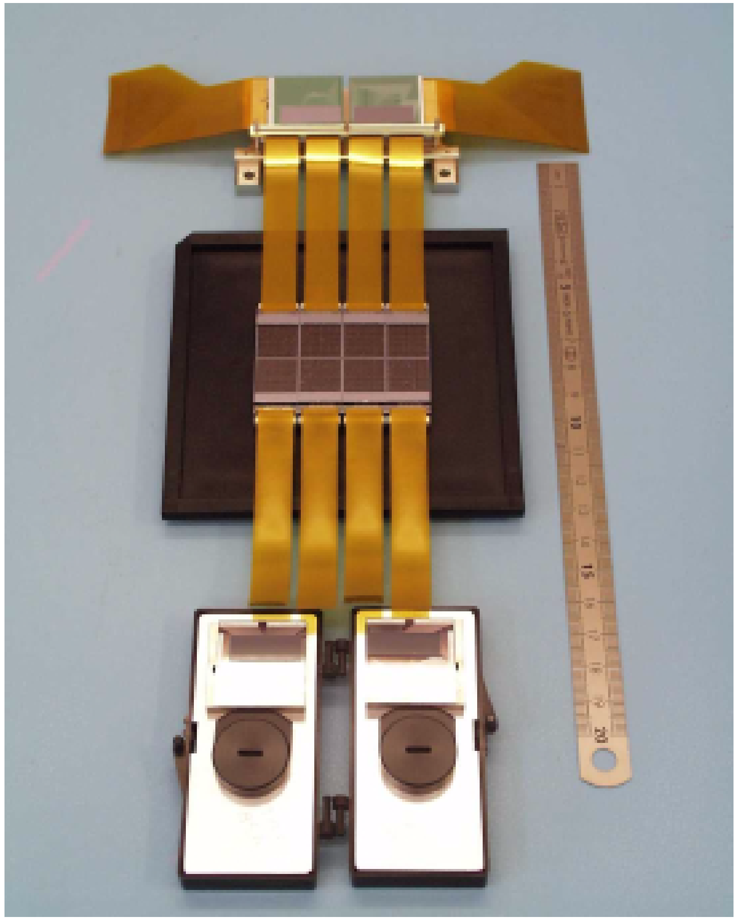


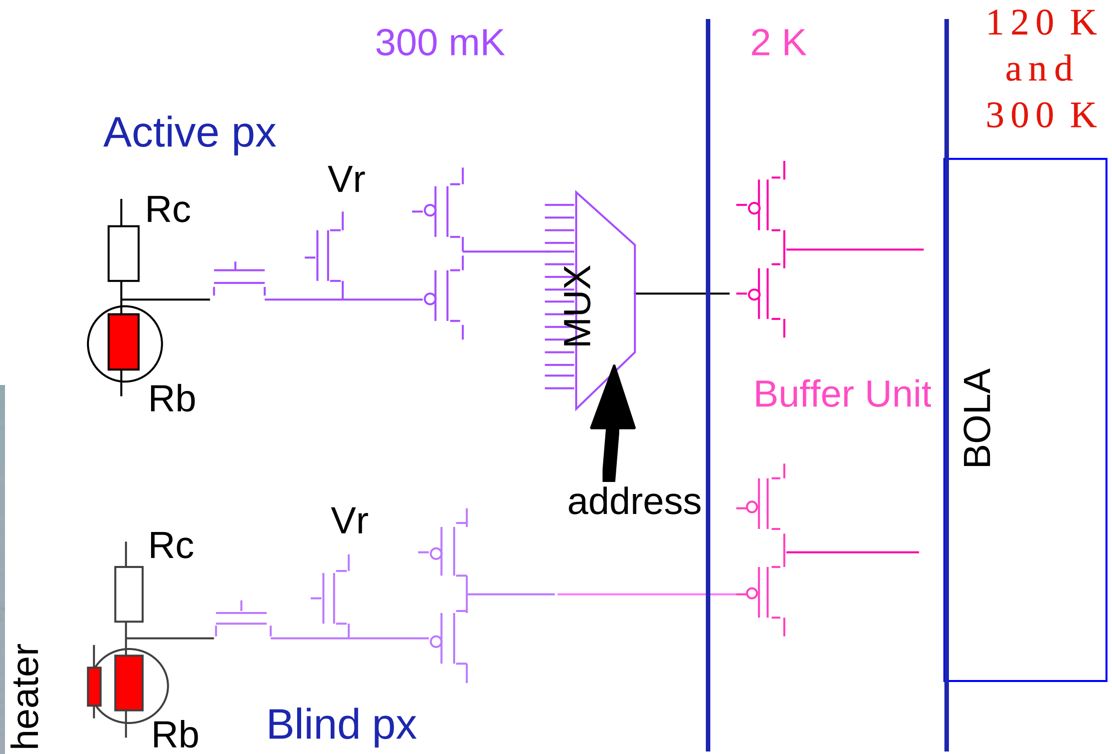
Grid design
For the PACS arrays



Theoretical absorption

Readout and signal processing



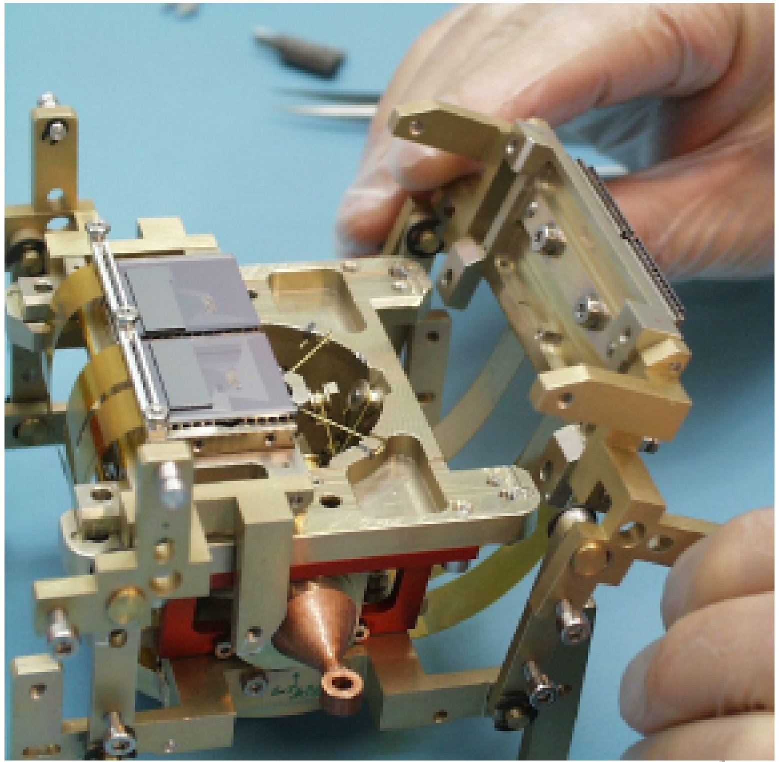


The cold electronic system ensures

a) the double correlated sampling to remove 1/f readout noise,

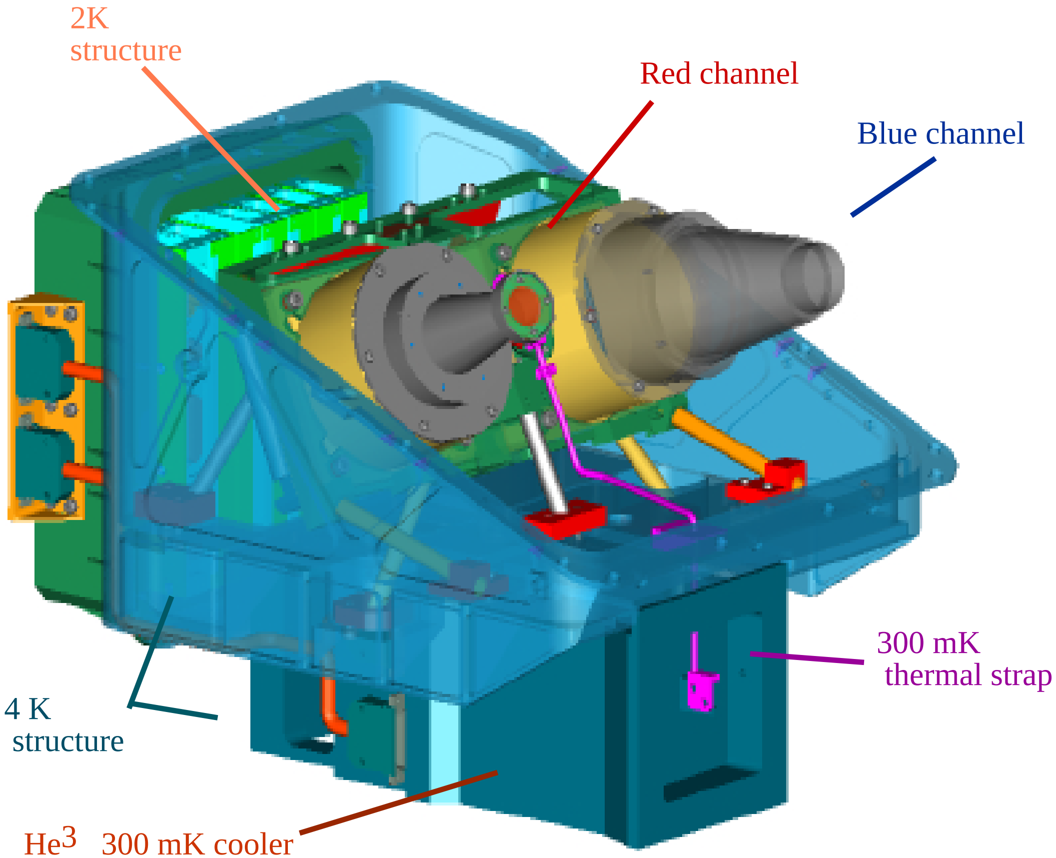
b) fully differential measurement with blind pixels to remove the external collective perturbations.

c) 16 -> 1 Multiplexing.



MECHANICAL & THERMAL DESIGN

Mounting of the arrays and associated 2K preamplifier



The 300 mK thermal stage is insulated from the 2 K stage thanks to kevlar® wires

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The suspension scheme was qualified in vibration tests at the ARIANE V nominal levels at warm temperature.

PACS Focal plane

FIRST RESULTS

All the pixel functionalities checked operational at 300 mK:
differential mode, double correlated sampling, multiplexing.

Thermal design: Demonstrated. A simplified array in operation achieved 280 mK on a 2 STP liter cryocooler.

Responsivity: Measured response to a bare 20 K blackbody: 10^{10} V/W. This value should be better in the photometer bands (filters not yet availables).

2 K Buffer Noise: The Buffer noise density was measured at 4K to be lower than 0.5 µV/√Hz @ 2 Hz

2 K Buffer Bandwidth & dissipated power:
The Buffer bandwidth with an output capacitance of 1 nf was measured to be 5,5 kHz (needed 3 kHz), for a total power charge on the 2K level of 2,8 mW (3.3 mW max allowed power for 2500 pixels).

PROSPECTS

The noise performances of the implanted Si thermometer and their associated MOS cold electronics are good enough to achieve BLIP conditions under hight background conditions, like in HSO or for direct imagery on ground based telescope.

The all Si based technology is the natural choice to manufacture large arrays with a good yield.

The vacuum resonant cavity achieved by indium bump can be adapted from 100 µm to 850 µm. It cannot be extended beyond 1 mm

A larger focal plane (4000 px) is foreseen for a balloon experiment: ELISA, in a wider wavelength range (100µm - 800 µm) (PI: I. Ristorcelli, CESR, France).